JP1.12

# THE IMPACTS OF MICROPHYSICAL SCHEMES AND PARAMETER CHOICES ON ICING DIAGNOSES USING THE UAF INTEGRATED IN-FLIGHT ICING DIAGNOSTIC ALGORITHM FOR ALASKA.

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## 1. Introduction

As described in a companion paper (Tilley et.al, 2002), we have developed an Alaskan in-flight icing diagnostic algorithm (hereafter noted UAF IIDA) derived from the NCAR/RAP Integrated Icing Diagnostic Algorithm (McDonough and Bernstein, 1999). This algorithm utilizes infrared satellite observations, pilot reports, surface observations and numerical forecast data from the PSU/NCAR MM5 mesoscale model version 3 MM5v3; Chen and Dudhia 2001).

As such, the quality of the simulated atmospheric fields of temperature and relative humidity, as well as associated cloud hydrometeor fields and microphysical processes, can have a substantial impact on the skill of the algorithm. This is especially true in high latitudes where conventional observations and pireps that would act in the algorithm to counteract model biases are scarce and satellite retrieved fields must sometimes be utilized with caution.

Thus, it is important to evaluate the degree of impact that the various MM5 microphysics schemes can have on high latitude simulations of fields important to and utilized within the UAF IIDA. In a separate companion paper (Tilley and Kramm 2002) we document the degree to which the choice of cloud microphysical schemes and parameters within those schemes affect cloud and precipitation fields produced by the MM5v3. In this study we extend those results by applying the various MM5v3 output fields to the UAF IIDA and intercompare the results to determine:

- a) whether the degree of variability seen in the cloud and precipitation fields by Tilley and Kramm (2000) is carried through to the predictions of the icing algorithm, and
- b) if the degree of variability is not carried through, does this fact reflect a problem with the algorithm that needs to be addressed or does it reflect the algorithm's strength in avoiding model biases?

The answer to question b) is by no means a trivial exercise given the degree that the UAF IIDA is based upon the NCAR/RAP IIDA, which has only recently begun testing in a high latitude environment. Given the higher incidence of mixed phase clouds within a generally colder temperature range than is common for mid-latitudes, it is reasonable to expect that additional tuning of the algorithm may be required to adequately represent the high-latitude microphysical environment.

In this paper, we present a brief introduction to the study, including summary information on the salient features of the MM5 simulation experiment design and the algorithm implementation. A sample of icing algorithm diagnostic results from the simulations shown in Tilley and Kramm (2002) will be presented. Contingency-table based verification statistics utilizing pilot reports (PIREPs) of observed icing or non-icing conditions will be presented at the conference.

## 2. MM5 simulation experiment design

A suite of simulations were performed with MM5v3 in which all model physics schemes were the same save the microphysical treatment. The simulation domain, which is also the icing diagnostic domain (Figure 1)covers most of Alaska at 18 km horizontal resolution, with 41 vertical sigma coordinate levels. All simulations utilized the Grell (Grell et al. 1991) cumulus scheme, the Burk and Thompson (1989) turbulence closure scheme, the Blackadar (1979) force-restore treatment of the soil surface and an improved version of the CCM2 radiative transfer scheme (Cassano et. al 2001).

Although a variety of microphysical schemes and parameter settings are examined in this study, for brevity in this paper we limit our

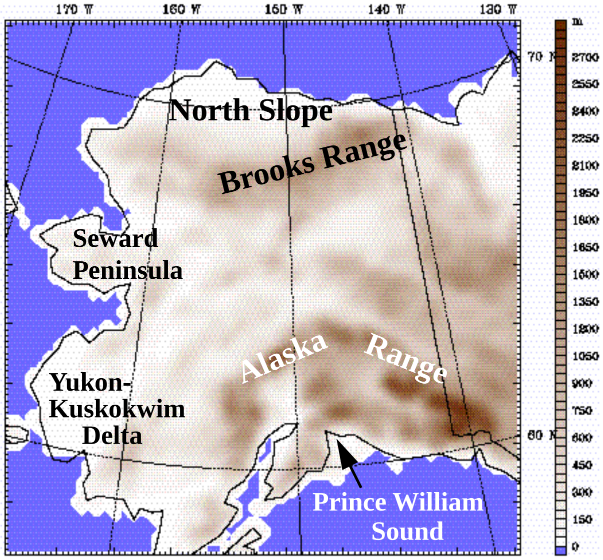


*Figure 1. Domain of MM5 simulation experiments. Grid resolution is 18 km; major terrain features are marked.*

consideration to the simulations illustrated in Figure 2 of Tilley and Kramm (2002). Specifically, these simulations include:

- a simulation with the scheme of Reisner et al. (1998; referred to as Reisner 1) that includes cloud and rain water, ice and snow, but does not consider riming processes and graupel formation,
- a simulation with the Schultz (1995) scheme that includes formation of ice, graupel and hail.
- a simulation that modifies the minimum temperature threshold for ice nucleation in the Reisner 1 scheme to 238K (referred to as R1-238); and
- a simulation that replaces the default Fletcher (1962) ice nucleation curve with that of Meyers et. al (1995), referred to as exp. R1-M.

Motivation for the latter two simulation experiments discussed here is provided in Tilley and Kramm (2002). To summarize, both of these modifications to the Reisner 1 microphysics scheme are pursued in an attempt to make the scheme more realistic for high latitude application by allowing for mixed phase clouds and ice nucleation processes at colder temperatures.

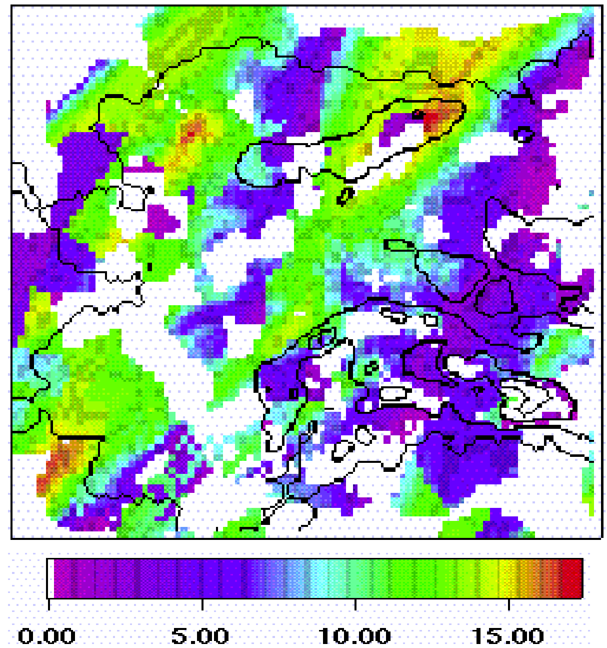


*Figure 2. Vertically integrated icing potential field for 00 UTC 15 June 1998.*

## 3. Case study

The case study period considered here (15-17 June 1998) falls during early summer over effectively the entire domain. This period is ideal for testing many aspects of the UAF IIDA since during this part of the year several different cloud and in-flight icing environments typically are present over Alaska. Convection occurs in Interior Alaska while low stratus clouds dominates the North Slope and maritime cloud systems, with a mixture of cloud types, occur over the southern third of the state. Such a variety of conditions represent different icing forecast problems and scenarios and are a good test for any algorithm intended for regional application.

The use of a historical dataset for these tests allows us several luxuries that do not necessarily exist in any operational implementation of this algorithm. In particular, all relevant observations can be utilized in the algorithm tests shown here; in an operational environment some observations would be missing from both the algorithm and the MM5 initial analysis. It is therefore appropriate to consider the results presented here to reflect a relatively optimal application of the UAF IIDA.

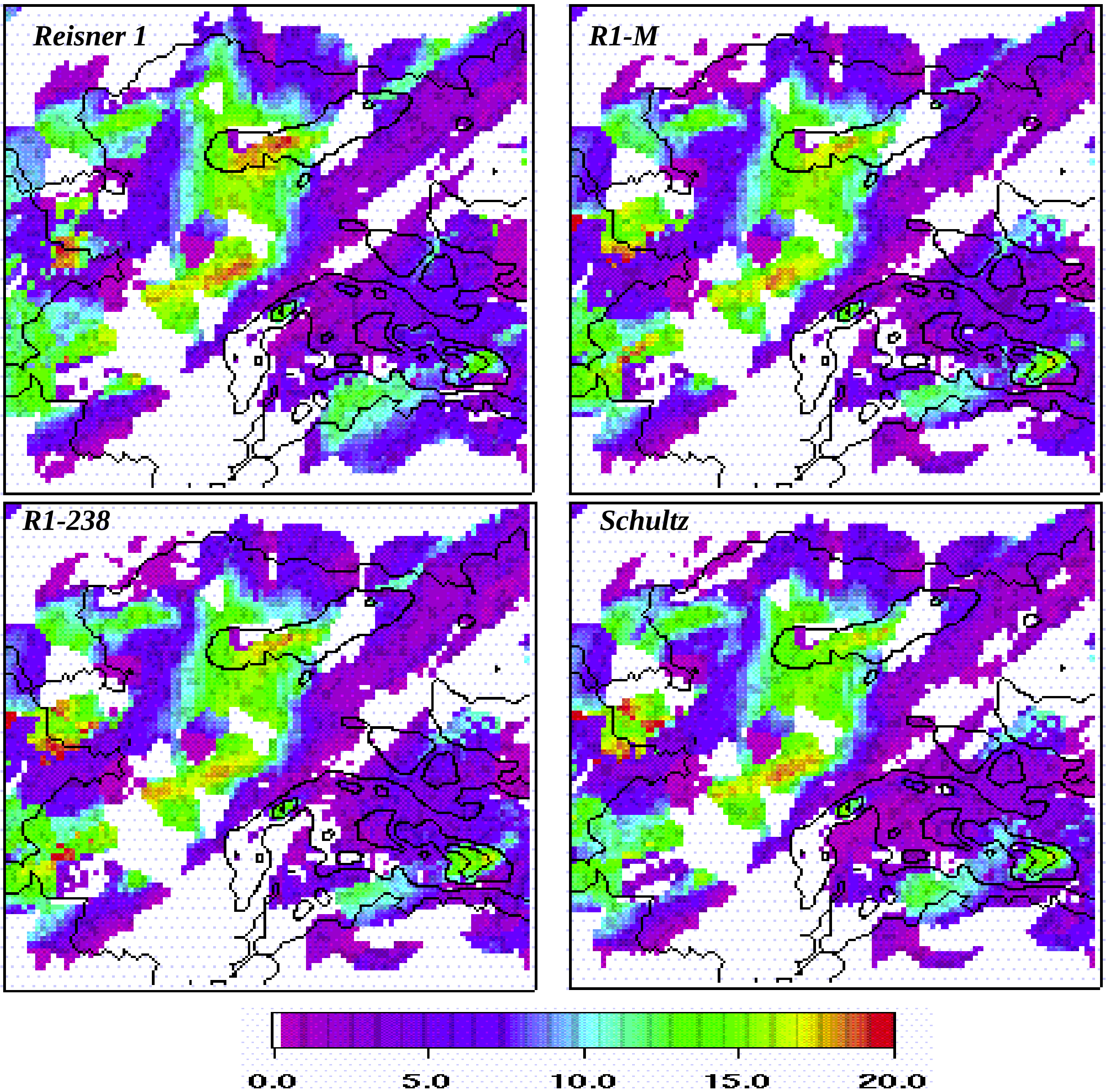


*Figure 3. Vertically integrated icing potential field for 00 UTC 15 June 1998 corresponding to the MM5 simulations denoted in text as a) Reisner 1; b) R1-M ; c) R1-238 and d) Schultz*

**4. Results**

Figure 2 shows output from the UAF IIDA at the initial time of 00 UTC 15 July 1998. The field that is illustrated is a vertically integrated icing potential field (values range from 0 to 100) and represents a worst-case diagnosis from the IIDA; effectively, all icing potential in the atmospheric column is summed to obtain the integrated values. It is important to note that this potential does not represent a probability in statistical terms, but rather a more general likelihood that icing conditions are possible at a location or within a grid column. As all aspects of the data input into the algorithm are the same (since microphysical differences are not yet manifest at the initial time), all four realizations of the UAF IIDA are identical at this point, as they should be. Some icing threat is indicated over much of the state but with the more serious threats over the North Slope, Brooks Range and southwestern areas of the state. These are areas which are climatologically favorable for icing conditions in early summer, particularly at low levels with freezing levels less than 6000 feet.

A more interesting result is shown in Figure 3, the predicted vertically integrated icing potentials at 24 hours into the forecast cycle (00 UTC 16 July 1998) from the simulations using the Reisner 1, R1-238, R1-M and Schultz microphysics schemes. We have chosen this second period for presentation for comparison with Figure 2 of Tilley and Kramm (2000), and for the fact that the 24- hour forecast time represented by these figures is probably the longest range icing product that could be considered useful by general aviation interests in rural Alaska.

The general predictions of vertically integrated icing potential shown by the four realizations of the UAF IIDA in forecast mode are rather similar at this forecast time. Mesoscale differences in the details of the forecast potentials do exist, however, with the greatest disagreement occurring over the central Brooks Range and North Slope areas, the Seward Peninsula, Yukon-Kuskokwim Delta and Prince William Sound. All of these areas have considerable single or twin-engine general aviation traffic. While the differences are relatively small in scale (300-1200 $km^2$) and in magnitude (less than 5% difference in the amount of the atmospheric column affected) in the Alaskan Bush, they would not necessarily be trivial in the context of a high-resolution icing diagnosis/forecast to Alaska bush aviators. Indeed, a present lack of quality fine-scale information and forecasts on the three-dimensional structure of icing hazard areas has been communicated to the authors as a source of considerable frustration to aviators in the Alaska bush. Further work to examine the three-dimensional structure of the icing potential fields is warranted and will be presented at the conference.

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